p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 1, page 40 - 50, October 2021
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Indonesian Journal of Urban and Environmental Technology
http://www.trijurnal.lemlit.trisakti.ac.id/index.php/urbanenvirotech

THE EFFECT OF ROTOR ROTATION SPEED ON DECREASED LABORATORY LIQUID WASTE POLLUTING PARAMETERS

Muhammad Al Kholif *, Joko Sutrisno, Indah Nurhayati, Retno Setianingrum

Study Program of Environmental Engineering , Faculty of Engineering, Universitas PGRI Adi Buana Surabaya, Indonesia

*Corresponding author: alkholif87@unipasby.ac.id

ABSTRACT

Laboratory wastewater is produced through laboratory activities. Laboratory wastewater can have a large impact on the environment if it is not processed before being discharged into the water body. Laboratory waste treatment can be carried out using suspended growth technology to reduce pollutant loads, especially Biological Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD). **Aims:** This study aims to treat wastewater produced by the activity of laboratory using suspended growth technology. **Methodology and Results:** This research was conducted by finding the most efficient rotor rotation in degrading the load of BOD5 and COD pollutants. The reactor used is a Mixed Flow Reactor type reactor made of acrylic material with a thickness of 5.5 mm. The reactor is arranged into three series with the same sampling time and different rotor turns that expressed in rotors per minute (rpm). The reactor series consists of Reactor I with 50 rpm rotor rotation speed, 100 rpm Reactor II and 150 rpm Reactor III. Processing is carried out using 8 hours of detention time and variation of sampling time every 8 hours. **Conclusion, significant and impact study:** From the results of the study obtained the highest level of effectiveness of reducing pollutant load on processing using 150 rpm rotor rotation and 40 hours sampling time which is 94.6% for BOD_5 parameters and 94.4% for COD parameters.

MANUSCRIPT HISTORY

- Received September 2021
- Revised September 2021
- Accepted October 2021
- Available online October 2021

KEYWORDS

- BOD_5
- COD
- Laboratory wastewater
- Suspended growth

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 1, page 40 - 50, October 2021
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

1. INTRODUCTION

Hazardous waste is waste that can or causes serious problems for health for both the environment and humans. This waste is classified as potentially high risk due to several factors such as persistent, toxic and even deadly even at very low concentrations (Devi *et al.,* 2018). Laboratory wastewater is one of the hazardous wastes that have high levels of pollutants. Pollutants contained in laboratory waste are the result of the accumulation of various chemical residues used in every task or work in the laboratory (Ho & Chen, 2018). The majority of waste generated from laboratory activities consists of used glassware rinse water reactions and disinfection equipment, water-based salt and buffer solutions, cell culture media, and alcohols with dilute concentrations (Klein, 2006). The use of chemicals in laboratory activities is the main cause of difficulty in laboratory waste to be processed (Benatti *et al.,* 2006).

The Environmental Engineering Laboratory of Universitas PGRI Adi Buana (UNIPA) Surabaya is one of the laboratories for testing samples from student activities such as practicums and sample analysis for research needs. Laboratory activities carried out in UNIPA Surabaya laboratory indirectly use the chemicals needed in conducting testing. The waste generated by Environmental Engineering laboratory of UNIPA Surabaya is mostly treated by third parties. Including solid waste generated from laboratory activities of Mineral and Coal commodities that produce more solid waste that belongs to Hazardous waste. Self-treated waste is domestic liquid waste from bathroom waste, pantry and waste from the sink. Liquid waste treatment conducted by Environmental Engineering Laboratory of UNIPA Surabaya uses a combined processing consisting of physics processing and chemical processing.

One type of biological processing is processing with suspended growth. Sewage treatment using Suspended Growth generally uses the process of mixing in forming a suspension containing the culture of microorganisms. According to Sugito *et al.,* (2016), processing using high organic loads can be done with anaerobic bio filters which are a type of biological processing with attached growth. Furthermore, according to Dabi (2015), processing using Suspended Growth has a 30% higher COD removal efficiency than with attached growth. The performance effectiveness of a suspended growth reactor can also be determined by how much cod levels are degraded by heterotrophic bacteria along with the absorption of a number of COD fractions including solid and colloidal particles (Smitshuijzen *et al.,* 2016).

The aim of this study was to assess BOD_5 and COD levels in the wastewater of laboratory of

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 1, page 40 - 50, October 2021
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Environmental Engineering UNIPA Surabaya by using suspended growth treatment. If reviewed from previous research conducted by Baddour *et al.,* (2016), waste treatment with suspended growth using a speed of 100 Rpm and combined with variations in sampling time between 3, 6, 9, 12, 15, 18, 21, 24, 27, 29, 31, 33, 35, 37 and 38 hours resulted in the highest COD removal efficiency of 94.1% obtained at the 38-hour sampling time. While the research conducted by Gulhane & Virkhare (2015), which uses rotor speeds of 50 Rpm and rotated for 24 hours has a TSS removal efficiency of 77.3% and COD of 88.7%. While in this processing the efficiency rate decreased BOD5 and COD levels above 90%.

2. RESEARCH METHODOLOGY

The study tested the extent of the effect of rotor spin on the decrease in BOD_5 and COD levels in laboratory wastewater with suspended growth treatment systems. This study was conducted experimentally by providing variations in time collection.

Processing using Suspended Growth requires perfect mixing in order to produce suspension that is used as a place for microorganisms to growth. In terms of stirring, the rotor has an important role in terms of forming the suspension. This research was conducted by applying variations of rotor rotation of 50 rpm, 100 rpm and 150 rpm on mixed flow reactor (MFR) type reactors with laboratory scale made of acrylic material thickness of 5.5 mm and has a reactor volume of 45 L as seen in Figure 1. In this study also given a variety of sampling done every 8 hours. The reactor is also equipped with a filter tube containing gravel media that fills 1/3 of the upper reactor chamber.

The reactor used consists of 3 reactors with each reactor given a different rotor rotation treatment. Rotor rotational speeds used include speeds of 50 rpm in reactor I, 100 rpm in reactor II and 150 rpm in reactor III. The speed of the rotor is regulated using a tachometer that has a working principle that measures the rotation speed of the rotor with a sensor expressed in rpm units. The rotor used is driven by a dynamo that has a power of 100 Watts.

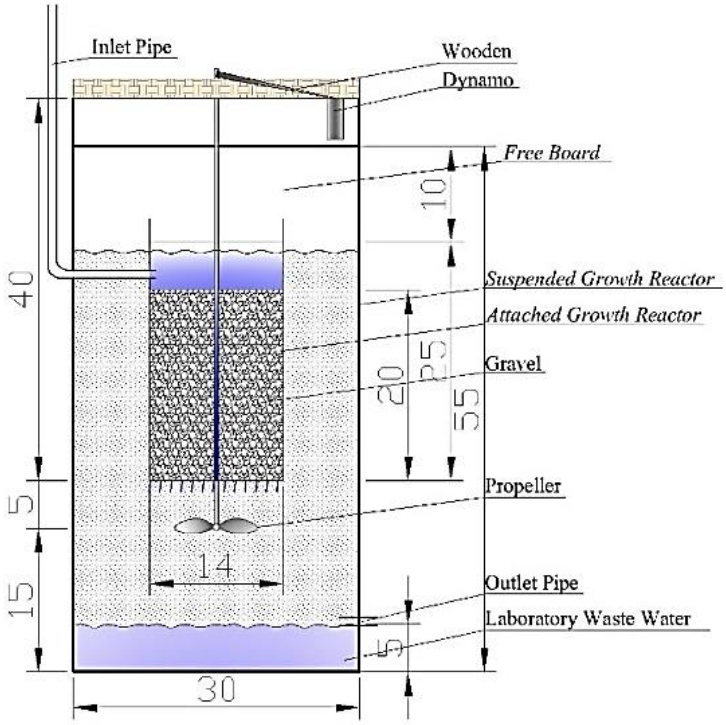

Figure 1 Research reactor

Before the wastewater is treated, a preliminary test is conducted that aims to find out the characteristics of the waste to be treated. The characteristics of laboratory waste based on preliminary observations in the laboratory waste of Environmental Engineering Laboratory of UNIPA Surabaya have a BOD_5 content of 484 mg/L and COD of 1881 mg/L. The value of the pollutant parameter is still above the quality standard based on East Java Governor Regulation No. 52 of 2014 which requires BOD_5 50 mg/L and COD 100 mg/L.

The wastewater to be treated, first passes through a filter tube containing gravel that serves as a filter of wastewater from its impurities. Wastewater is treated using rotors at a certain speed. Then sampling is done every 8 hours to analyze the load of BOD5 polluters with winkler and COD methods with titrimetry methods. From the results of the analysis obtained the level of allowance of polluting load after processing by looking at the comparison between influent and effluent. From the comparison, then searched the efficiency of removal of BOD_5 and COD polluter load expressed in percentage.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 1, page 40 - 50, October 2021
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

3. RESULTS AND DISCUSSION

3.1 Preliminary Analysis

Preliminary analysis is carried out to find out the characteristics of laboratory wastewater to be treated. The initial concentration of BOD_5 and COD obtained is then compared with the quality standard to then be assessed whether the laboratory waste is suitable for processing or not. In addition to BOD_5 and COD parameters, wastewater is also measured by its pH and temperature. The results of the preliminary analysis are listed in Table 1.

Table 1 Preliminary analysis of laboratory wastewater

Parameters	Unit	Inlet	Quality Standards	Method
pH	-	6.8	6.0 - 9.0	SNI 3553:2015 Item 3.3
Temperature	^oC	28.8	-	2550 B
BOD_5	mg/L	484	50	5210 B
COD	mg/L	1881	100	5220 B

The Table 1 provided that the wastewater to be treated has a very high polluting load in this case, wastewater that has these characteristics needs to be treated using suspended growth. Measurement of pH and temperature of wastewater before and during treatment is also carried out in order to obtain relevant treatment data. The pH and temperature data of wastewater during the treatment process are listed in Table 2.

From Table 2 below it can be seen that treated wastewater has a pH and temperature that is quite stable and still enters the quality standard for pH parameters.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 1, page 40 - 50, October 2021
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

Table 2 Data pH and wastewater temperature

No.	Rotor Rotation	Time Retrieval	pH		Temperature (^{0}C)	
			Inlet	Outlet	Inlet	Outlet
1	50 rpm	0 hours	6.80	6.85	28.8	28.9
		8 hours	6.85	6.90	29.2	29.4
		16 hours	6.90	7.02	29.4	29.6
		24 hours	7.02	7.14	29.6	29.4
		32 hours	7.14	7.20	29.4	28.9
		40 hours	7.20	7.20	28.9	28.8
2	100 rpm	0 hours	6.80	6.90	28.8	28.9
		8 hours	6.90	6.90	28.9	28.6
		16 hours	6.90	6.95	28.6	28.9
		24 hours	6.95	7.11	28.9	29.5
		32 hours	7.11	7.14	29.5	28.9
		40 hours	7.14	7.14	28.9	28.9
3	150 rpm	0 hours	6.80	6.85	28.8	28.8
		8 hours	6.85	6.90	28.8	28.7
		16 hours	6.90	7.00	28.7	28.9
		24 hours	7.00	7.10	28.9	28.9
		32 hours	7.10	7.06	28.9	28.8
		40 hours	7.06	7.03	28.8	28.8

3.2 Seeding and Acclimatization

The acclimatization stage is seen based on the stability of the growth rate suspended by microorganisms in the reactor. The test used to determine the level of stability of the acclimatization period is to analyze the testing of organic substances with the permanganate method. The stage of organic substance testing is carried out in the first week before the analysis of BOD5 and COD. According to Al Kholif, (2013), in the processing attached growth using bioball media the seeding and acclimatization process lasted for 10 days while in this study, seeding and acclimatization lasted for 7 days to get a steady state condition and ready for processing. To find out the condition of the steady state in the wastewater to be treated, a permanganate test is carried out.

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 5, Number 1, page 40 - 50, October 2021
Accredited SINTA 2 by Ministry of Research, Technology, and Higher Education of The Republic of Indonesia No. 23/E/KPT/2019 on August 8th, 2019 from October 1st, 2018 to September 30th, 2023

3.3 Analysis of Concentration Data Before and After Processing

In general, this study applies 2 processing systems assembled in one processing reactor. The system used is the Attached Growth system applied to gravel media tubes and suspended growth system which is used as the main processing in processing laboratory waste.

Before treatment with a Suspended Growth system, laboratory wastewater is first streamed to a gravel media filter tube (Attached Growth System). Results obtained from the Attached Growth processing system showed that the value of BOD_5 decreased from 484 mg/L to 455 mg/L and for the value of COD decreased from 1881 mg/L to 1827 mg/L. Data obtained from the processed results attached growth for the overall rotor rotation obtained a decrease value of BOD_5 of 29 mg/L and COD of 54 mg/L. The following table 3 shows a decrease in levels in the parameters of the BOD_5 and COD tests. BOD_5 obtained from the processing results shows the amount of oxygen needed by microorganisms in degrading the burden of polluters biologically.

Table 3 Concentrations of BOD_5 and COD before and after processing with suspended growth

No.	Rotor Rotation	Time Retrieval	BOD concentration $_5$		COD concentration	
			Influent (mg/L)	Effluent (mg/L)	Influent (mg/L)	Effluent (mg/L)
1	50 rpm	0 hours	484	455	1881	1827
		8 hours	455	267	1827	1045
		16 hours	267	204	1045	818
		24 hours	204	154	818	648
		32 hours	154	108	648	429
		40 hours	108	82	429	327
2	100 rpm	0 hours	484	455	1881	1827
		8 hours	455	386	1827	1543
		16 hours	386	276	1543	1083
		24 hours	276	144	1083	560
		32 hours	144	93	560	376
		40 hours	93	77	376	315
3	150 rpm	0 hours	484	455	1881	1827
		8 hours	455	375	1827	1496
		16 hours	375	124	1496	642
		24 hours	124	57	642	225
		32 hours	57	36	225	155
		40 hours	36	26	155	106

Table 3 shows a decrease in concentration in both BOD_5 and COD parameters on the

effect of rotor rotation used by reactors. Based on the table can be seen the difference in the load content of BOD_5 and COD between the variation in sampling time of 8 hours, 16 hours, 24 hours, 32 hours, and 40 hours. This is because the length of processing time can determine how much efficiency the level of efficiency decreases polluter load (Al Kholif & Hermana, 2013). Processing time has an influence for microorganisms to grow and develop effectively so that the longer the processing time is done, the more organic loads are degraded.

In this study, the highest reduction in BOD_5 and COD levels was obtained at 150 rpm rotor rotation with the longest sampling at 40 hours so that when compared to sampling conducted at 8 hours, 16 hours, 24 hours and 32 hours, processing for 40 hours was more effective in degrading BOD_5 and COD polluter loads. This is because the 40-hour processing gives microorganisms a longer time to degrade the load of BOD_5 and COD pollutants.

3.4 Removal Efficiency of BOD_5 and COD

The removal efficiency of BOD_5 and COD is provided in the following graph presented in Figure 2 and Figure 3 below.

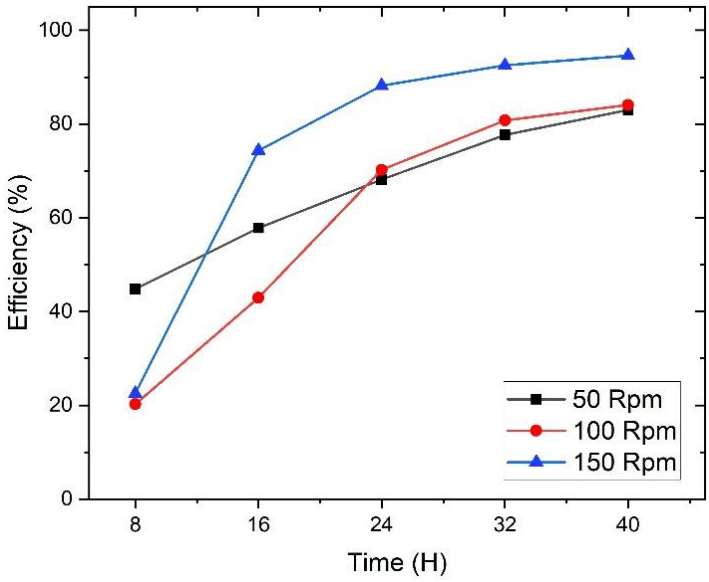

Figure 2 BOD_5 Removal efficiency

From Figure 2 it is found that the longer the sampling is carried out, the higher the percentage of BOD_5 removal is obtained, both in reactor I, reactor II and reactor III. The graph also shows a high percentage of removal in reactor III which uses a speed of 150 rpm. From these results it can be seen that the highest BOD_5 removal efficiency is 94.6%, when compared to previous research conducted by Gulhane & Virkhare (2015) which uses processing with rotor speed of 60 rpm the highest BOD removal efficiency is only obtained at 77.3% (this is because in previous research using 1 reactor with a change in speed between 50 rpm and 60 rpm treatment so that the rotor does not function optimally in treating wastewater. In a study conducted by Suzuki *et al.* (1999), the process of processing suspended growth showed the best performance when combined with the processing of attached growth using biofilm processes and was treated to three zones consisting of anaerobic, anoxic, and aerobic biofilm processes in the form of media that are fluidized in the aerobic zone. In the study, nitrification was done by nitrifiers in biofilms while for denitrification and phosphorus transfer was done by active mud.

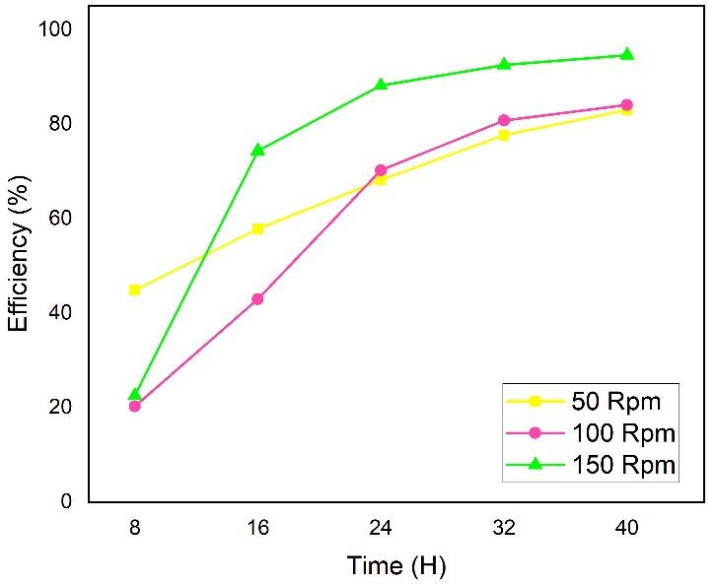

Figure 3 COD removal efficiency

Figure 3 shows an overview of the efficiency of decreased COD levels using the processing of suspended growth expressed in percent. From Figure 3 it can be seen that the highest efficiency of COD removal is obtained at 40 hours sampling. The graph also shows a high percentage of removal in reactor III with a speed of 150 rpm from which the results can be seen

that the highest COD removal efficiency is 94.4%, when compared to previous research conducted by Baddour *et al.,* (2016) which uses aerobic moving bed biofilm reactor and uses rotor rotation speed of 100 rpm cod removal efficiency obtained is 94.1%.% This research is considered as effective as previous research although the technology used is different, namely in previous research using biofilm moving bed technology while the technology used in this study uses suspended growth.

4. CONCLUSION

The rotor rotation speed used in this study had an effect on the decrease in BOD_5 and COD removal in laboratory liquid waste. The most effective rotor rev speed in lowering BOD_5 and COD polluter loads is the rotor rotation speed of 150 rpm at a sampling time of 40 hours by producing BOD_5 removal of 26 mg/L or with efficiency of 94.6% and COD removal of 106 mg/L or with an efficiency of 94.4%. Testing laboratories that have the same waste characteristics can apply processing with suspended growth to treat the resulting laboratory waste. But in order to provide processing with a higher level of efficiency and meet local quality standards, this processing can be combined with other processes such as processing using bio-filter systems. In addition, further research can also be done that is useful to review the effectiveness of processing suspended growth with other different variables.

5. ACKNOWLEDGEMENT

Researchers received support from UNIPA Environmental Engineering Laboratory Surabaya Surabaya. And the author would like to thank Mr. Slamet who has helped in the assembly of tools and all those who have participated in the process of completing this research that cannot be mentioned one by one.

REFERENCES

Al Kholif, M. 2013. Anaerobic Biofilter Application on Laundry Wastewater from Chicken Slaughterhouse [Institute of Technology November Ten]. http://digilib.its.ac.id/ITS-paper-33021140003343/28903.

Al Kholif, M., & Hermana, J. 2013. The Wastewater Treatment of Chicken Slaughterhouse by Using Submerged up flow Anaerobic Biofilter. *4th International Seminar Department of Environmental Engineering Department of Environmental Engineering, Institut Teknologi*

Sepuluh Nopember Public Health Program Study, Medical Faculty, Udayana University, 1-7.

Baddour, E., M., Farhoud, N., Sharholy, M., & Magid, I.M. A. 2016. Biological Treatment of Poultry Slaughterhouses Wastewater by using Aerobic Moving Bed Biofilm Reactor. *International Research Journal of Public and Environmental Health.* 3(5):96-106. http://www.journalissues.org/IRJPEH/http://dx.doi.org/10.15739/irjpeh.16.013.

Benatti, C., T., Tavares, C. R. G., & Guedes, T. A. 2006. Optimization of Fenton's Oxidation of Chemical Laboratory Wastewaters using the Response Surface Methodology. *Journal of Environmental Management.* 80(1):66-74. https://doi.org/10.1016/j.jenvman.2005.08.014

Dabi, N. 2015. Comparison of Suspended Growth and Attached Growth Wastewater Treatment Process: A Case Study of Wastewater Treatment Plant at MNIT, Jaipur, Rajasthan, India. *European Journal of Advances in Engineering and Technology*. 2(2):102-105. www.ejaet.com.

Devi, K., Oggu, S., & Singh, T., C. 2018. Hazardous Waste Management in India - A Review.

Gulhane, M., L., & Virkhare, M. 2015. Attached Growth System Assisted Oxidation Ditch Government College of Engineering, Amravati, Maharashtra, India. *International Journal For Scientific Research and Development.* 3(01): 1138-1139.

Ho, C., C., & Chen, M., S. 2018. Risk Assessment and Quality Improvement of Liquid Waste Management in Taiwan University Chemical Laboratories. *Waste Management.* 71(September): 578-588. https://doi.org/10.1016/j.wasman.2017.09.029.

Klein, R., C. 2006. Research Laboratory Wastewater Neutralization Systems. *Journal of Chemical Health & Safety*. 13(2): 15-18. https://doi.org/10.1016/j.chs.2005.02.004.

Regulation of the Governor of East Java Number 52 of 2014. About Wastewater Quality Standards for Industry and/or Other Business Activities, 2014.

Smitshuijzen, J., Perez, J., Duin, O., & van Loosdrecht, M. 2016. A Simple Model to Describe the Performance of Highly-Loaded Aerobic COD Removal Reactors. *Biochemical Engineering Journal*. 112. https://doi.org/10.1016/j.bej.2016.04.004.

Sugito, Binawati, D., K., & Al Kholif, M. (2016). The Effect of BOD Concentrate Influet to Remove Pollutant Load in Waste Water of a Chicken Slaughterhouse. *ARPN Journal of Engineering and Applied Sciences*. 11(5): 3519-3524.

Suzuki, Y., Takahashi, M., Haesslein, M., & Seyfried, C., F. 1999. Development of Simulation Model for a Combined Activated-Sludge and Biofilm Process to Remove Nitrogen and Phosphorus. *Water Environment Research.* 71(4): 388-397. http://www.jstor.org/stable/25045231.